



ACTAR TPC project

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Outline

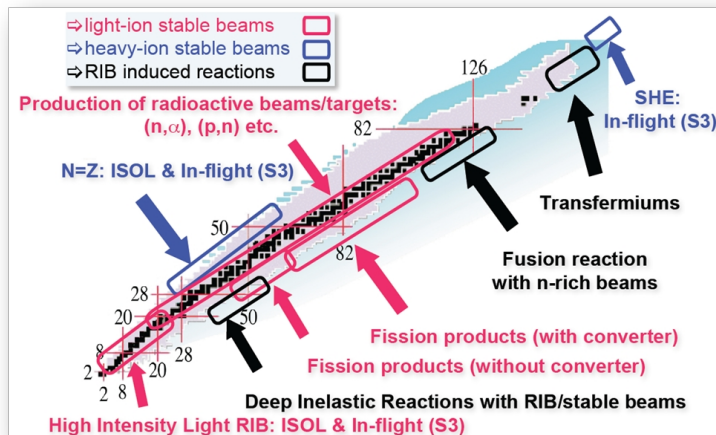
- Motivation and principle
- ACTAR TPC project
- Future opportunities

Motivation and principle: RIBs

Goal: studying the evolution of nuclear structure far from stability

Opportunities at the present and future RIBs facilities:

- Nuclear reactions
- Exotic decays



Challenges:

- The most exotic beams: very weak intensity
- Inverse kinematic: limit on E resolution from straggling in the target

Thin target ($\leq 100 \mu\text{g}/\text{cm}^2$)

→ resolution $\sim 300\text{keV}$

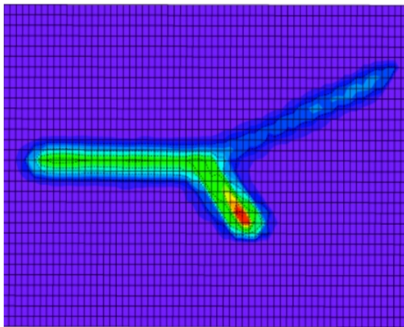
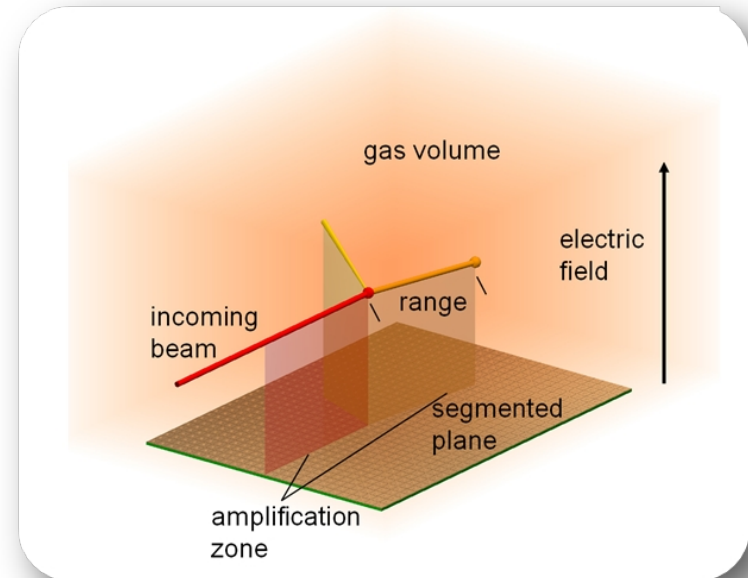
Thick target ($500\text{-}1000 \mu\text{g}/\text{cm}^2$)

→ to improve the efficiency

Motivation and principle: Active target concept

- **Time-Projection Chamber (TPC)...**

- Electrons produced by ionization drift to an amplification zone
- Signals collected on a segmented “pad” plane: 2d-image of the track
- 3rd dimension from the drift time of the electrons



- **...+ the detection gas is the target**

- Large (and adjustable) target thickness and still good resolution
- Vertex reconstruction:
1 mm at 1 bar pressure $\rightarrow 15 \mu\text{g}/\text{cm}^2$
- Good efficiency, low detection threshold

ACtive TARget Time Projection Chamber

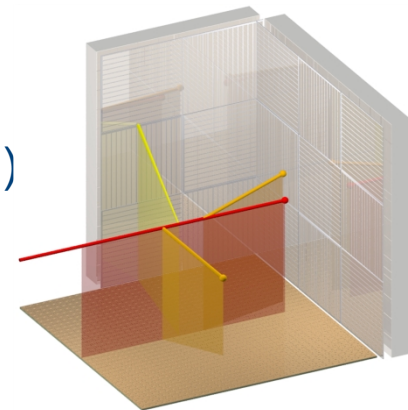
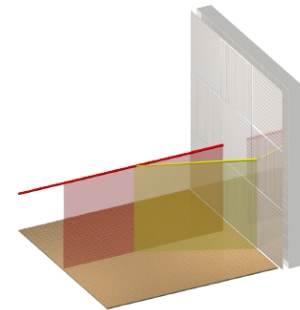
ACTAR TPC is a detector development project to realize a next-generation gas-filled detection system for studying the structure and decays of the most exotic nuclei.

ACtive TARget Time Projection Chamber

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Overcoming the limits of present active targets:

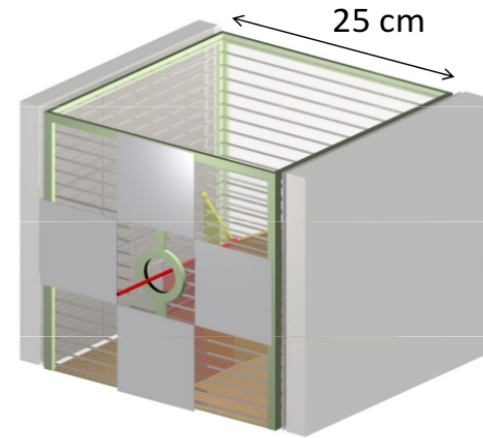
- Increase the dynamic range (10^3)
- Detect multi tracks
- Ensure a good position (energy) resolution
- Improve acceptable counting rates and beam intensity (10^6 pps)
- Design an instrument versatile, reconfigurable, portable



ACTAR TPC project:

The active target with a difference

- Segmented pad plane
 - Total of 16384 pads, $2 \times 2 \text{ mm}^2$
 - Cubic geometry (128x128)



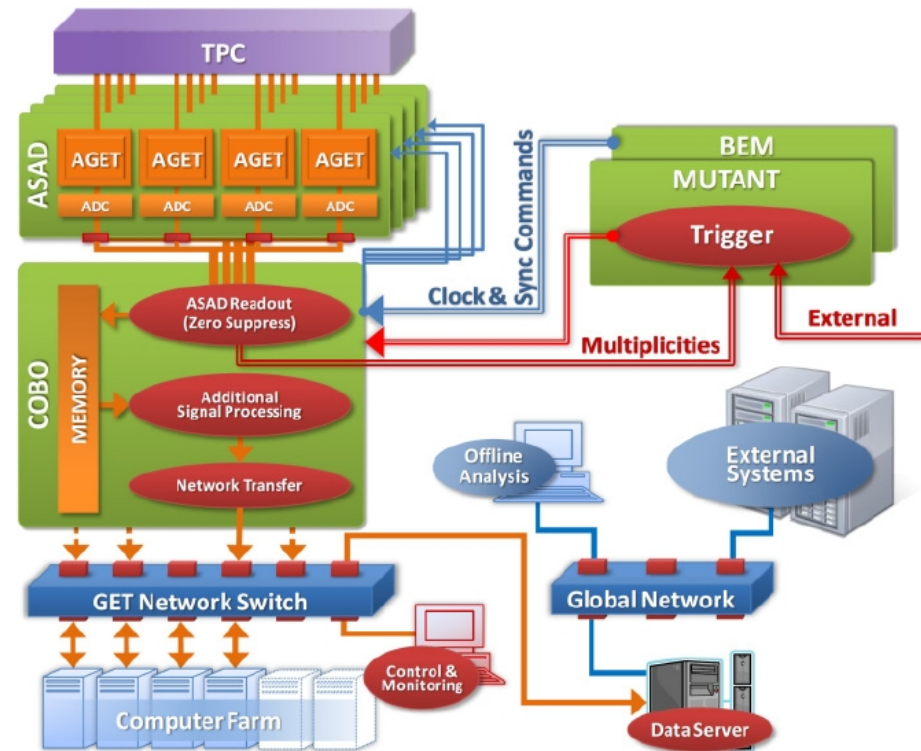
ACTAR TPC project:

The active target with a difference

- Segmented pad plane
 - Total of 16384 pads, $2 \times 2 \text{ mm}^2$
- Fully new data acquisition system
 - GET project: IRFU, CENBG, GANIL, RIKEN, NSCL

ACTAR TPC project: General Electronic for TPCs -GET

- High front-end density
- Portability
- High S/N ratio
- High dynamic range (possibility of different gain zones)
- Manage time stamp, other detectors, controls
- Intelligent trigger (external, multiplicity, topology)

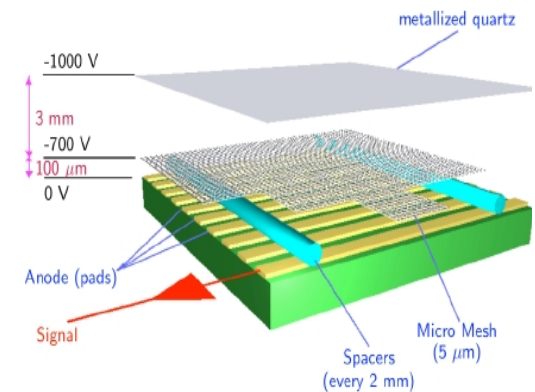


ACTAR TPC project:

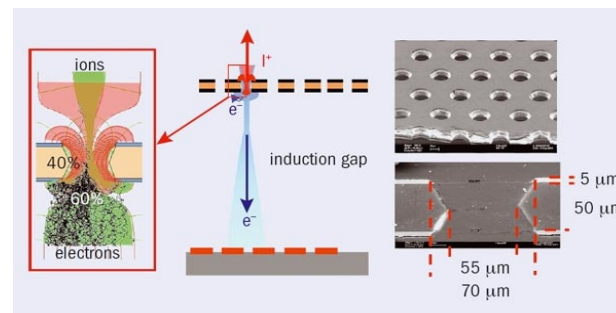
The active target with a difference

- Segmented pad plane
 - Total of 16384 pads, $2 \times 2 \text{ mm}^2$
- Fully new data acquisition system
 - GET project
- Amplification region
 - Micro-Pattern Gaseous Detectors
 - High rate capabilities (fast signals)
 - Very robust against electronic discharge
 - Different gain zones

Micromegas



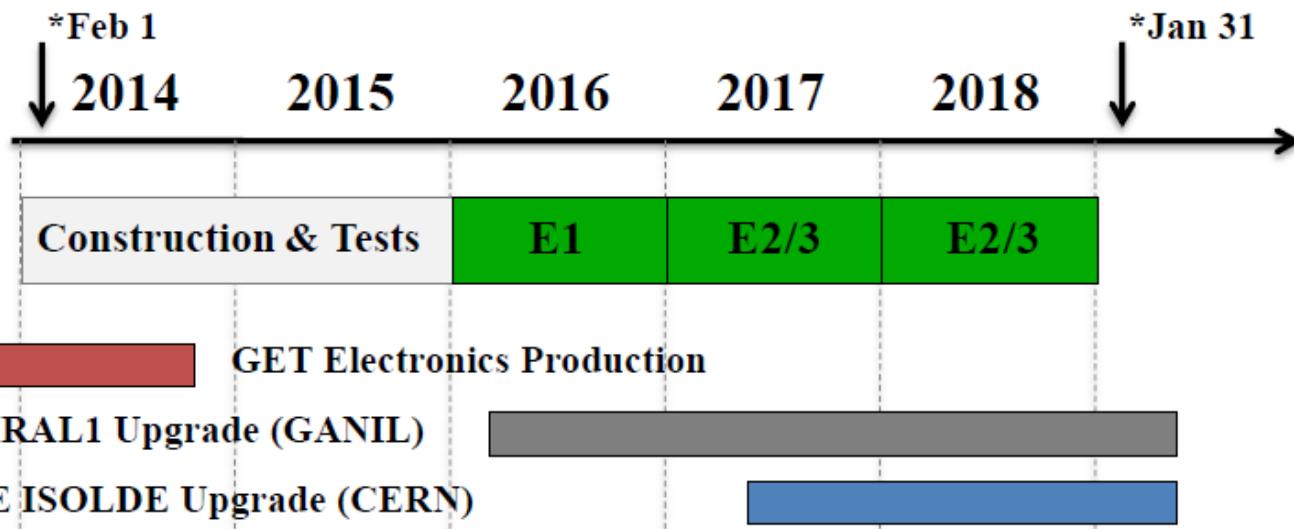
GEM



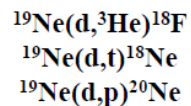
ACTAR TPC project: Status

G. Grinyer, 2013

ACTAR TPC

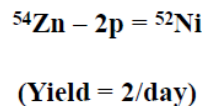


E1: rp-process @ SPIRAL



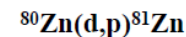
Goals: Breakout of CNO cycle in supernovae, commissioning

E2: 2p radioactivity @ LISE



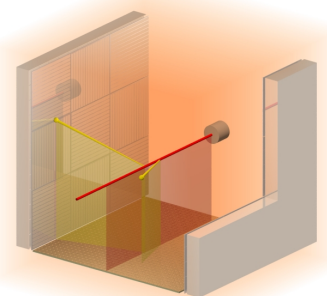
Goals: Angular correlations of emitted protons to ^{52}Ni (Z=28)

E3: r-process @ ISOLDE



(Yield* = 20/day)

Goals: Deduce N=50 shell gap near ^{78}Ni , start of the r-process?



Future opportunities

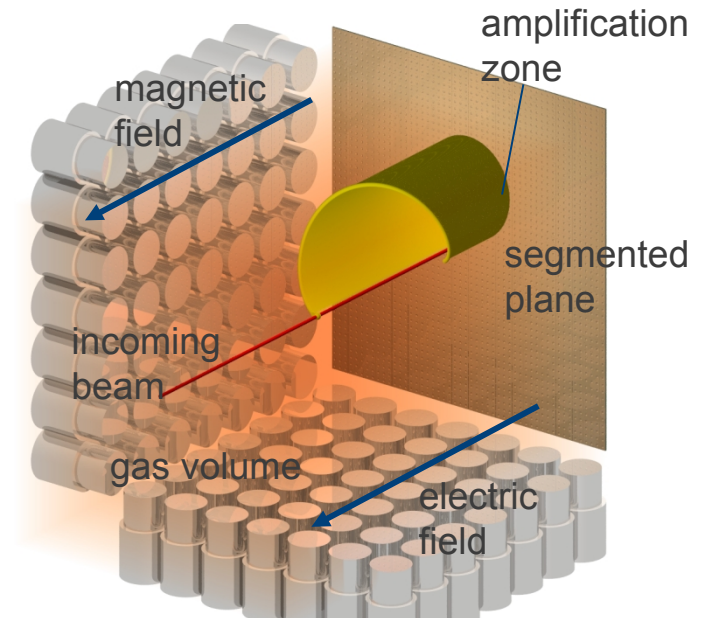
Two ERC Grants!!

R. Raabe (2013)



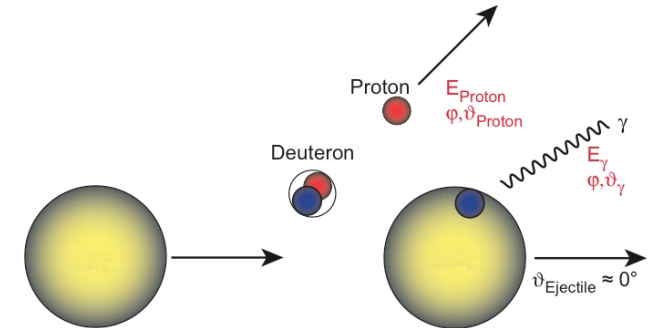
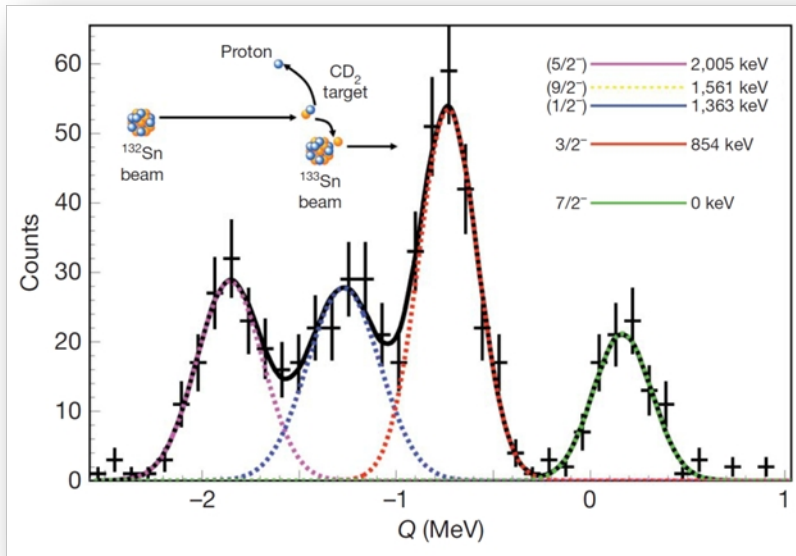
European Research Council
Established by the European Commission

- Active target: Time-projection chamber where detection gas is the target
- Array of γ -ray detectors within the field
LaBr₃ preferred for best compromise efficiency/resolution
- Magnetic field parallel to beam direction to confine emitted particles



Future opportunities

(d,p) reaction



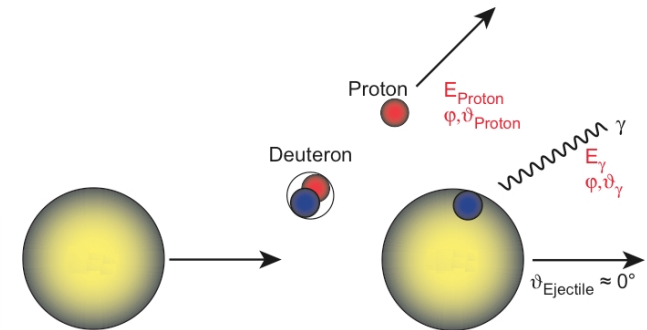
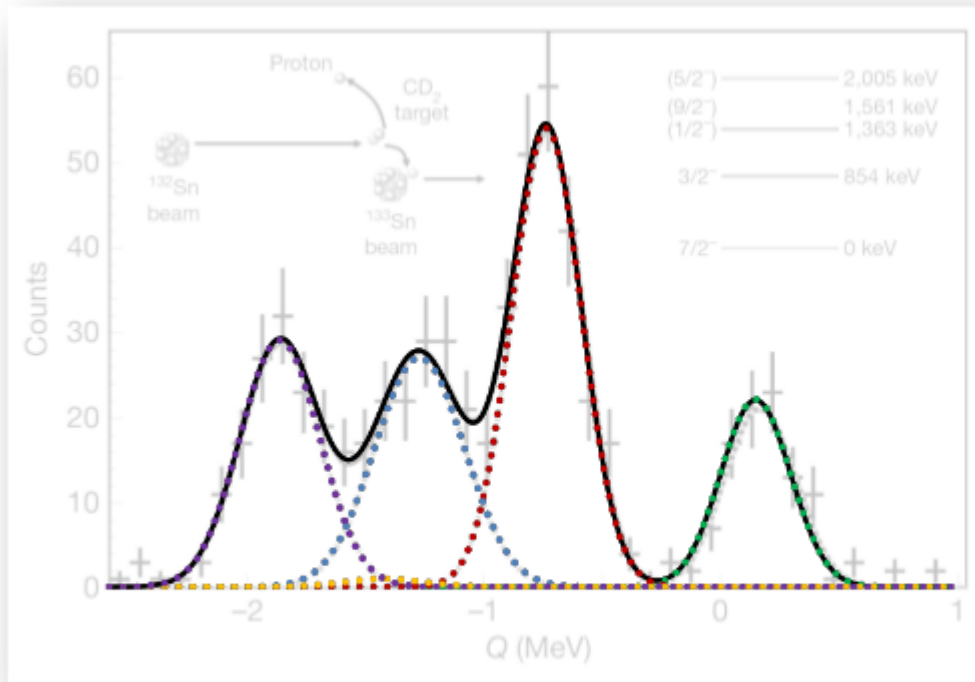
- $^{132}\text{Sn}(d,p)$
CD2 target $160 \mu\text{g}/\text{cm}^2$

➡ Resolution $\approx 300 \text{ keV}$

[K.L. Jones et al., Nature 465 (2010) 454]

Future opportunities

(d,p) reaction

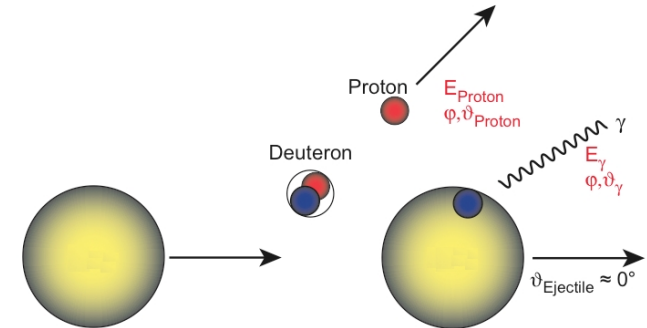
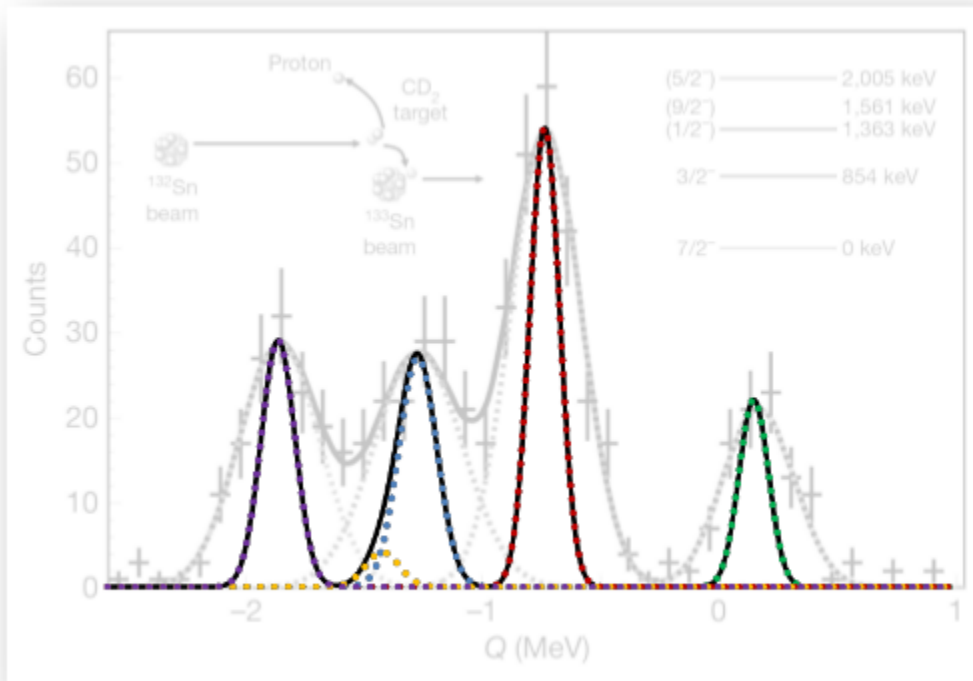


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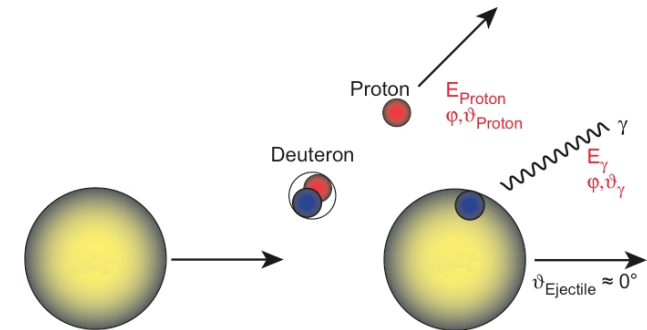
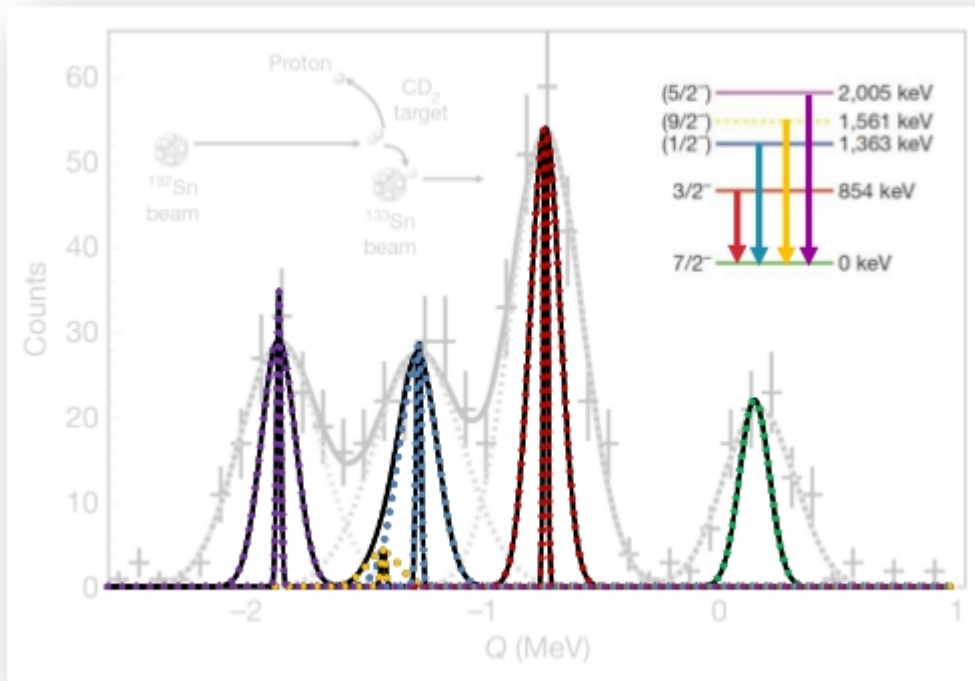


- $^{132}\text{Sn}(d,p)$ 5MeV/nucleon
D2 target 400mbar pressure

➡ Resolution $\approx 110\text{keV}$

Future opportunities

(d,p) reaction



ACTAR TPC

- improved resolution
- higher luminosity
- and** γ -rays detection system
- unique improvement!

The ACTAR TPC collaboration

- GANIL
- IPN Orsay
- CENBG Bordeaux
- IRFU/CEA Saclay
- IKS-KU Leuven
- University of Santiago de Compostela

Summary

ACTAR TPC project to develop a new generation of active target

- large target thickness *and* good resolution
- event-by-event reconstruction
- low thresholds
- high dynamic range
- high event rate
- all track detected
- highly reconfigurable detector
- new amplification technology
- new full data acquisition system

ACTAR TPC will be a very effective tools for research with exotic beams!



Thank you!

any questions?